'OSCAR' MP3 Player (2)

Part 2 (final): operation and measurement results

Design by A. Kurpiers and V. Pantelic

The OSCAR MP3 player is operated according to a new, intuitive concept which is vastly different from anything you've seen on conventional audio equipment.

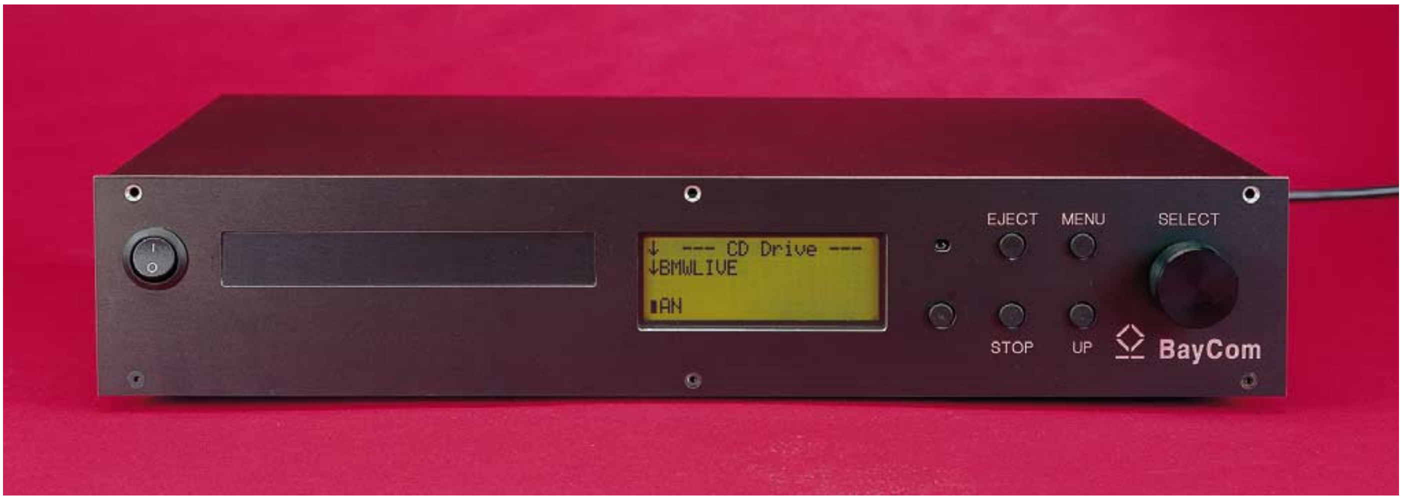


Figure 1. Front panel of the ready-built unit with all controls and the LCD.

Although there are no hard and fast 'rules' for the format of a CD or hard disk when it comes to song titles and the order in which they are stored, it is useful and convenient to arrange for an MP3 CD or a hard disk filled with MP3 tracks to have a hierarchical structure as we know it from working with a PC. Using a fixed structure ensures that you do not loose track (literally…) of your favourite songs. After all, an MP3 CD may contain over one hundred tracks, and a hard disk, thousands, so you have to get organised!

When in playback mode, OSCAR not only indicates the song title, but also the directory structure. This allows meaningful names to be assigned at all three levels (Directory/Subdirectory/File). For example,

Artist/Album/Song.mp3.

Another example is shown in the screendump in **Figure 3**.

Keypad

To prevent an unwieldy number of functions and options coupled to an equally large number of key combinations, most functions and settings may be reached via a hierarchical menu structure. Only five keys are required, each with a specific function, plus a rotary encoder with a key function. You will also look in vain for a display that's only capable of showing a couple of numbers and some special symbols. OSCAR has a 4-line LC display that allows all relevant information on song title or operation to be shown in plain text.

On the front panel of OSCAR (**Figure 1**) you'll find the five pushbuttons, the rotary encoder and the LC

Measurement results

Parameter	MP3-Player	Audio-DAC 2000 with S/PDIF-extension
Nominal effective output voltage	1 V	2.1 V
Level 20 kHz	–0.95 dB	–1 dB
Output impedance	1 kΩ	100 Ω
Signal/Noise ratio (no signal)	–96 dB	–111 dB
THD+N (1 kHz, B = 80 kHz)	0.17 %	0.0037 %
IMD (60 Hz:7 kHz = 4:1, 0 dB)	0,06 %	0.009 %
Channel separation 1 kHz	>100 dB	>115 dB
20 kHz	>76 dB	>90 dB
Lower roll-off frequency (10 kΩ load)	17 Hz	DC-coupled

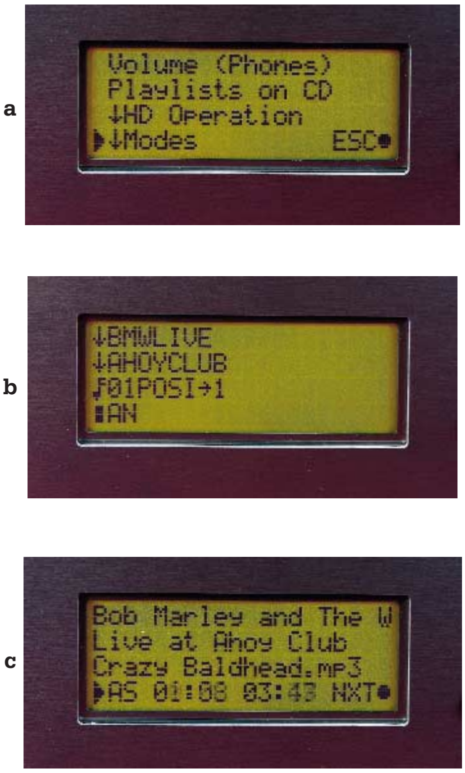


Figure 2. LC Display in three different modes:
a) Menu Mode
b) Select Mode
c) Playback Mode
The current application of the Softkey always appears in the lower right-hand corner.

display, besides the mains switch and the IR remote control 'eye'.

EJECT
This allows the CD-ROM drive tray to be opened and closed. This function also works while a track is being played from the hard disk.

SELECT and **UP**
SELECT gives access to the rotary encoder, which also acts as a normal pushbutton. The rotary encoder is the central control element, allowing quick access to the (vast number of) songs on the CD or the hard disk, as well as to the plethora of functions and settings offered by the menus. The operation is not unlike that of a mobile phone, and you will soon get the hang of it. To select a song or a directory, you simply turn the knob until the desired entry is found. Next you press (click) the encoder knob to select a directory, song or function.

Once you are in a menu, menu options may be picked by turning and clicking. If you end up in the wrong directory or subdirectory, you can go to the upper directory by pressing the UP button, and from there, go to the main menu. If OSCAR is fitted with a hard disk, the UP button allows you to choose between CD player and hard disk at the top directory level.

While in 'play' mode, turning the rotary encoder enables you to skip tracks or go back in the track list. The menu allows you to assign either function to the knob.

MENU
This is where the central control of OSCAR is stored. The menu allows all settings to be performed and stored. The complete overview of available commands may be found on the Elektor website (free downloads section, October 20000). You can leave the menu by using MENU, UP or ESC•.

STOP
Ends playback mode.

SOFTKEY
Although this key does not have a proper name, it does give access to a number of functions. The currently active function is shown in the right-hand bottom corner of the display:

NXT•	*Go to next track*
PRG•	*Add title to playlist*
Enter•	*Quit text entry*
ESC•	*Terminate operation*
DEL•	*Clear title storage in radio mode*

LC Display

The LCD can operate in one of three different modes: selection display, playlist display or menu display.

Menu display (Figure 2a)
The readout appears after pressing thre MENU button, and enables you to navigate through the equipment settings. The dark triangle ('Play' sign) points at the menu entry. A 'down' arrow in front of an entry indicates that a subdirectory is available. The current function of the SOFTKEY is shown in the right-hand bottom corner of the display.

Selection display (Figure 2b)
In this mode you can select a certain songtitle or directory. The 'down' arrow then indicates a directory, the character ≡ stands for .m3u-playlist, while the musical note sign points to the MP2/3 track.

The bottom line indicates the selected playback mode and its current status. The symbols used are the same as seen on conventional audio equipment. So, the dark square will be recognized as the STOP sym-

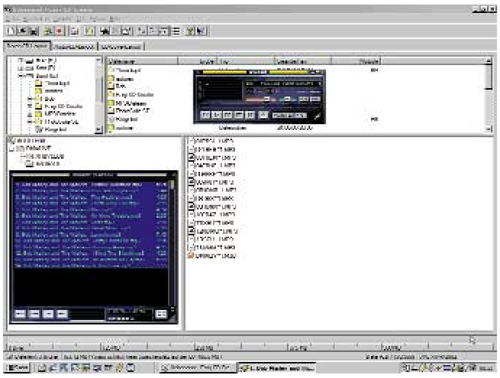


Figure 3. Ready to burn! The Explorer shows the directory structure (lower left), with beside it the lowest directory level containing all mp3 tracks and the m3u playlist.

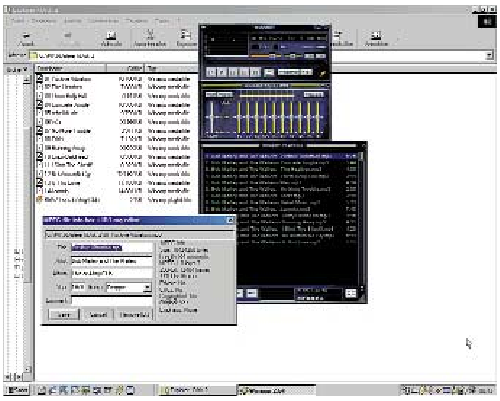


Figure 4. Using the Winamp ID3 Tag Editor (lower left) you can save information like Artist, Song Title, and Album. If required, this information is indicated on the LCD.

bol. Next to the STOP symbol is the play mode (1st position) as selected in the Menu/Mode, or the shuffle mode (2nd position). For example, 'AN' on the display means All Songs, Normal order (see table).

Playback mode (Figure 2c)
This is the normal readout during playback. The first three lines originate from the MP3 tag. In the fourth line, the display shows the current status (here, a Play symbol), followed by playback/shuffle mode (PS = random selection from a playlist), the track duration and the remaining time. The current function of the SOFTKEY is again shown in the right-hand bottom corner of the display (NXT = next track).

Playlists and Programmes

Besides the direct selection of tracks it is possible to define the order in which tracks are played in a so-called playlist, which was created before the CD was 'burned' or the hard disk was given its structure on the PC. Thanks to Winamp, M3u playlists now abound on the web. They may, however, also be made with other software MP3 players. When creating an MP3 CD, it is best to save the playlist in the lowest directory level, together with the MP3 files. This is illustrated by **Figure 3**, see the sub-window in the right-hand bottom corner of the CD burner program. Although this method provides structure and order, OSCAR is also capable of handling playlists separately from the tracks. In fact, they may be selected via a dedicated menu option (Playlists on CD).

It is not absolutely necessary to compile the playlist beforehand, however, as OSCAR can also do this. Simply go to the Program mode (via MENU – MODES – PLAYMODE – PROGRAM) and select songs or entire subdirectories in the usual manner using UP/SELECT. Using the SOFTKEY (PRG•), the selected track may be included in the playlist. As soon as a programme exists, only the programmed tracks are played (press SELECT to start). To play other tracks, you may either select another play mode, or start a non-programmed title using SELECT. When OSCAR is switched off, the programmed playlist is cleared. To prevent this, you may save a programmed playlist on hard disk using MENU – PROGRAM – SAVE PROGRAM. OSCAR will then prompt you for a name to be given to the playlist. You may enter the name by turning and clicking SELECT. The storage operation is initiated by the SOFTKEY. The target directory for the playlist may be selected before saving, via MENU – HD OPERATIONS – SET DESTINATION. The contents of the current playlist may be examined via MENU – PROGRAM – VIEW PROGRAM.

VBR and VB3

The acronym VBR stand for Variable Bit Rate and allows the degree of compression to be optimised depending on the programme material. If 'not much' is heard in a piece of music, the amount of data will be relatively small. Consequently the bit rate of the MP3 format is reduced. Conversely, a loud crescendo with its large amounts of data will cause the bit rate to go up again. To prevent the time display to change abruptly as a result of the continuously changing bit rate, OSCAR handles a VBR header loaded at the start of the MP3 track, thereby ensuring a steady and reliable readout of the song duration.

At the end of an MP3 file one often finds the so-called ID3 tag. This is special data set containing information not only on artist, album and song title, but also on production date and musical classification. This information may be quite useful if the file name does not say it all!

ID3 tags may be created with the ID3 tag generator function of Winamp. The screendump in Figure 4 shows that the *ID3 tag generator* not only saves text, but also infor-

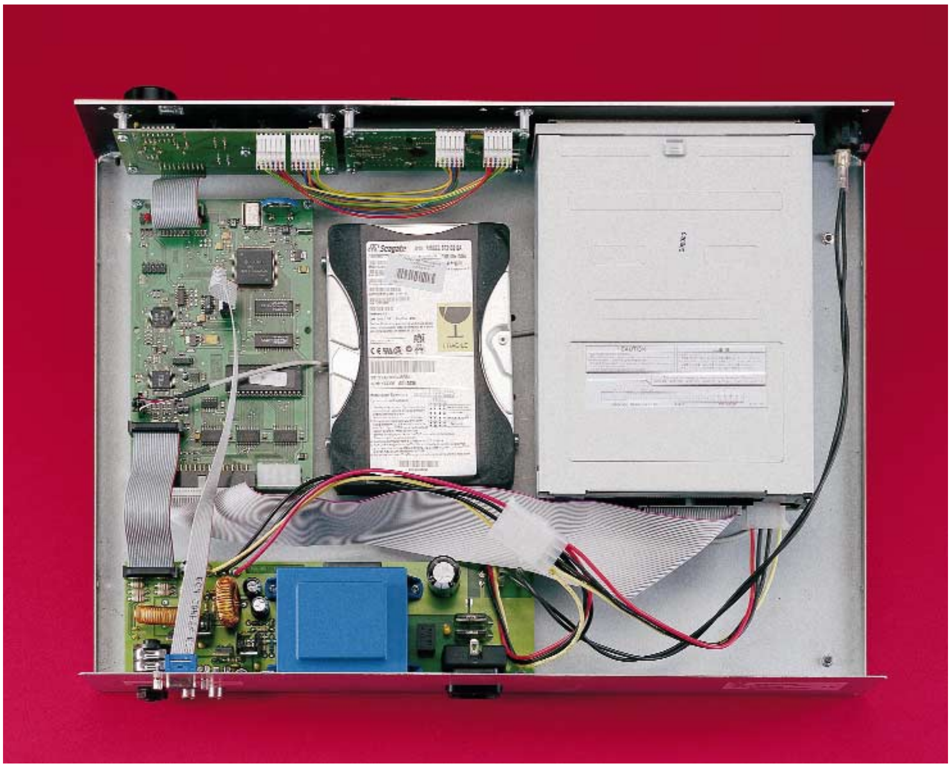


Figure 5. A look inside the case of a fully loaded OSCAR.

mation on the file format, in the *MPEG file info box*. If available, and if so desired, textual information is indicated when the song is played.

Select, Wind, Control

As already mentioned, the rotary encoder has several functions while a track is played on OSCAR. These functions may be defined via MENU – MODES – WHEELMODE. In 'Select' mode, you may search and select the next track. In 'Cue' mode, turning the encoder knob produces the 'fast forward' and 'fast rewind' functions. The 'Speed' mode, finally, enables you to control the playback speed without affecting the pitch. This is made possible by OSCAR's special way of pre-processing the MP3 data in, and is **unique** as far as we know. Within a span of ±10%, audible degradation is hardly noticed, while the function should induce experimentation! The current speed is shown in the right-hand bottom corner of the display. With normal audio CDs, the settings 'Cue' and 'Speed' are associated with the functions 'fast forward' and 'fast reverse'.

CD-ROM or hard disk?

In the (not unlikely) case of your collection of MP3 CDs starting to cause serious storage problems, OSCAR should be fitted with a hard disk for increased storage capacity. Currently available storage capacities of modern hard disks should provide ample for a vast music collection stored in a single piece of equipment. The hard disk may be formatted in OSCAR. By pressing a button, individual songs, whole directories or even complete MP3 CDs may be copied on to the internal hard disk. OSCAR also allows directories to be created, song titles to be cleared, and the HD free space to be indicated. Alternatively, the hard disk may be formatted and 'recorded' in the PC, for use later in OSCAR.

OSCAR supports the widely used FAT16 and FAT32 file systems.

OSCAR will work with any modern hard disk with a capacity greater than 1 Gbyte and supporting LBA mode. The actual capacity

Construction variants

OSCAR may be obtained from Baycom as a ready-built unit or a kit, including remote control. The kit, priced at £149 contains the stuffed main and front boards (including display) and an extensive construction manual. The more extensive variant priced at £249 also includes a CD-ROM drive, a steel case and the PSU board. A 20-GB hard disk is available as a further option. Because there is hardly any solder work to do, we can concentrate on a few details. The photograph shows the ingredients of the kit. The following items should be added: case, cables and a few mechanical and electromechanical parts, a power supply and at least one drive unit, that is, you need to add your own CD-ROM player and/or hard disk drive (unless, of course, you buy the extensive kit).

PSU:

The power supply unit (PSU) has to be capable of supplying voltages of +5 V at 2 A and +12 V at 2 A.

CD-ROM and hard disk:

Both drive units are connectd to the main board by a 40-way IDE cable with a maximum length of 50 cm. If no hard disk is used, the CD-ROM player is set to Master mode. If a hard disk is used, this is assigned the 'Master' function — the CD-ROM drive then becomes the Slave. To be able to play normal audio CDs you'll need a screened cable between the CD-ROM drive and the main board.

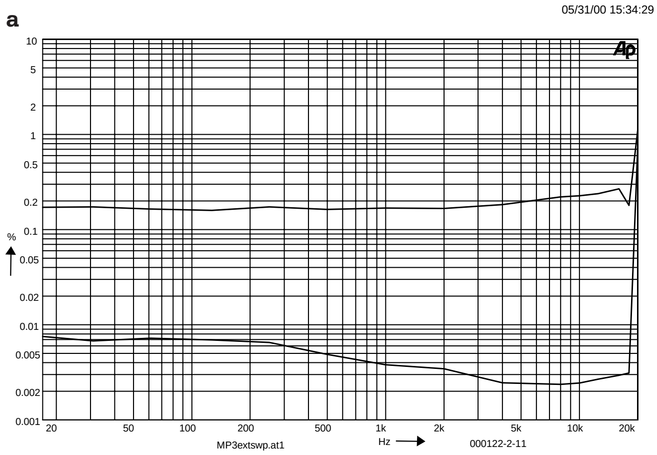
LCD and Keyboard

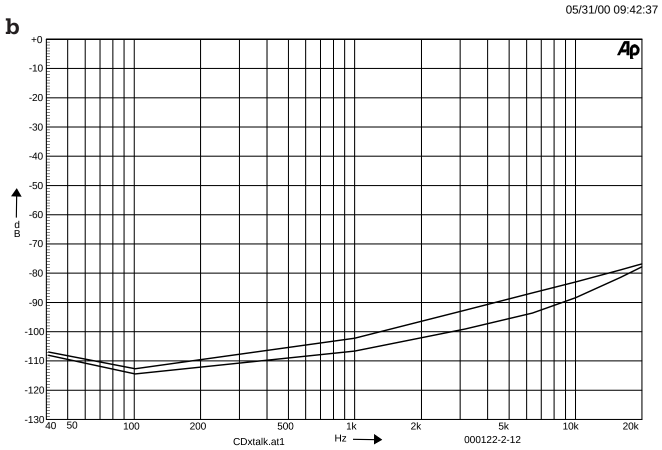
A 20-way flatcable with a maximum length of 50 cm connects the keyboard and the main board. The link between the keyboard and the display is two times 6-ways. To be able to adjust the LCD contrast with the case closed, a small hole should be drilled below the cermet preset.

Additional parts to fit on the case:

Front side: mains switch (illuminated), stereo headphones socket
Rear side: IEC mains appliance socket (with in-built fuseholder), 2 Cinch sockets, 9-way RS232 chassis-mount socket (female).

Obviously, there is nothing against turning OSCAR to the standard audio source in your car! Unfortunately, CD-ROM drives are susceptible to strong mechanical shocks and vibrations that may occur in car. If you are firmly intent on equipping OSCAR with a CD-ROM drive in your car, be sure to use a spring suspension system. Hard disks, too, should benefit from rubber suspension, although no problems were encountered in practice. We recommend using 2.5-inch HD drives as applied in notebook computers. In a car, the cable between the main board and the display should not be longer than about 50 cm. Essential, but also problematic in a car, is the availability of a sufficiently stable supply voltage. Because the terminal voltage of a car battery may vary between 8 V and 14 V, you'll need to use a combined step-up/step-down converter to generate regulated +5 V and +12 V rails. A suitable circuit is planned for publication on the OSCAR homepage as well as in Elektor Electronics.





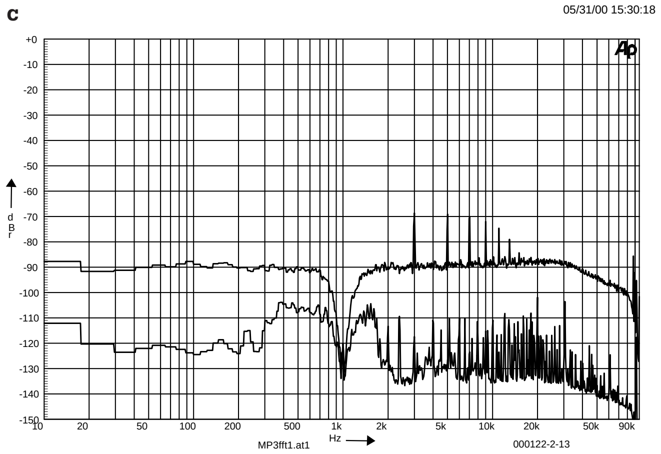


Figure 6. OSCAR on the rack:

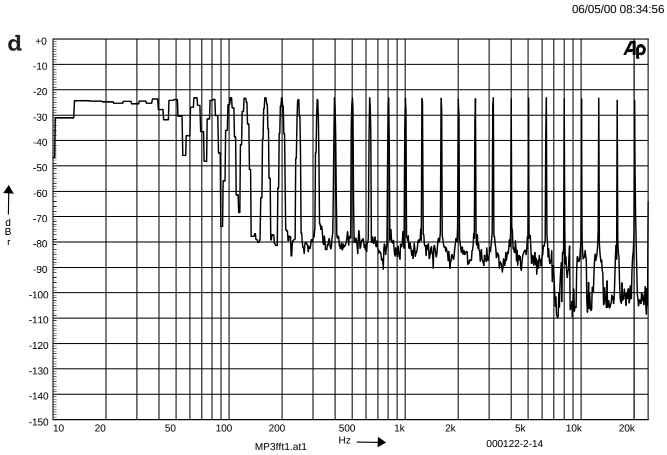
a) THD + N

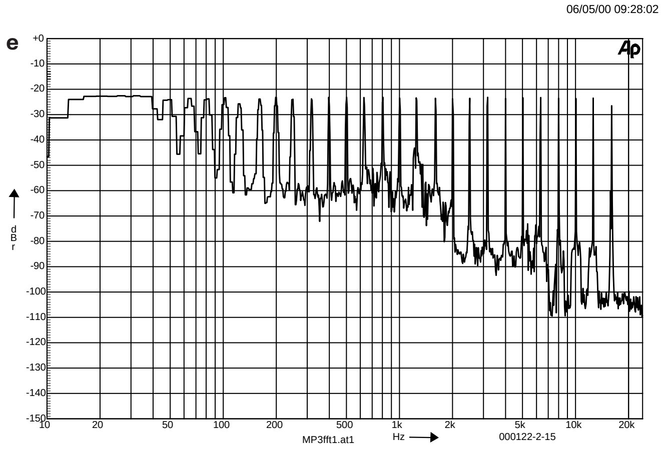
b) Crosstalk

c) Spectral analysis of a 1-kHz signal

d) Spectral analysis of a multitone signal encoded using the Fraunhofer encoder.

e) as d), but using the Xing encoder.





of the hard disk is immaterial — even 60 Gbyte ones will work without problems. **Figure 5** shows a fully loaded OSCAR with an internal hard disk.

Update

With PCs, software updates seem to be required on a monthly basis. By contrast, the update phenomenon is unknown in the field of hi-fi equipment. The operating system for OSCAR is subject to constant extension and improvement. Updates may be downloaded free of charge from the OSCAR homepage http://www.oscar-mp3.de An update may be downloaded and either burned on a CD, or sent to OSCAR via the PC and the RS232 serial port. The communication settings are 115 kbit/s, 8 data bits, 1 stop bit, no parity.

Many suggestions and wishes of existing OSCAR users have already found their way into the current version of the operating system, and many more are expected after publication of this article. However, note that it is not (yet) possible to send MP3 files to the OSCAR hard disk by way of the RS232 port.

Measurement results

As a matter of course, OSCAR was subjected to an extensive series of (gruelling) tests in the *Elektor Electronics* audio laboratory. A number of test CDs were purposely encoded as MP3 files. The encoder used was L3enc V. 2.72 from the Fraunhofer Institute, set to the highest resolution (128 kbit/s, f_S = 44.1 kHz).

The measurements were not only carried on OSCAR itself, but also in conjunction with the high-end *Audio DAC 2000* published by this magazine. For this to work, a special S/PDIF extension had to be devleoped first. This design appears elswewher in this issue. As you can see from the measured values and curves, it makes sense to employ a high-end external converter, even though the measurement results are a far cry from the behaviour of the Audio DAC 2000 with real S/PDIF signals (see *Elektor Electronics* January 2000).

Curve 1
A comparison of the harmonic distortion plus noise indicates that the analogue audio circuitry in OSCAR is not up to the performance of a high-end converter. At 1 kHz, the distortion of the Audio DAC 2000 is 45 times lower than that of OSCAR. The measurements were carried out in a bandwidth of 80 kHz. The jump in the curves at about 20 kHz is caused by the discrete measurement points at 18 kHz and 20 kHz. In reality, the curves extend to almost 20 kHz.

Curve 2
shows the channel separation at the linear output of the MP3 Player. Up to 1 kHz, the signal is clearly affected by noise.

Curve 3
The top curve shows the frequency spectrum of the MP3 Player at a 1-kHz signal at maximum volume (0 dB). The noise floor is relatively high at –90 dB, and harmonic distortion is clearly visible.

The lower curve shows the result of the same measurement, but then at the output of the audio DAC (i.e., OSCAR acting as a digital signal source). The noise floor is 20-30 dB lower than with Curve 3, and harmonic distortion is down by no less than 40 dB. The curve also shows the effect of masking in MP3: the noise floor around the (suppressed) 1-kHz test signal is clearly higher than in the other ranges. Moreover, a series of mixing products is created.

The test session also included measurements using multitone signals (31 frequencies, 1/3th octave distance and 20 kHz). Below 100 Hz, the curves provide little useful information — the 'flat' response is caused by the linear resolution. In reality, however, there are also a couple a discrete frequencies with a noise floor as in the rest of the frequency range.

Curve 4
Shows the frequency spectrum with a similar multitone measurement, this time captured at the output of the MP3 Player. The spectrum was also measured at the output of the Audio DAC (via the above mentioned S/PDIF converter). The curve, which is not shown here, was not significantly different — only the noise floor was about 7 dB lower overall. When compared with the 1-kHz measurement, the noise floor with complex signals is about 30 dB higher than with a single discrete frequency.

Curve 5
Here you can see that the playback quality is heavily dependent on the quality of the MP3 encoder. The test setup is the same as that for Curve 4. However, we used the (fast) Xing MP3 Encoder V1.5 to encode the multitone spectrum. A quick comparison indicates that frequencies above 16 kHz are simply suppressed, although *High Frequency Mode* was set to 20 kHz. The noise floor is very irregular — even below 2 kHz, noise is 20 dB higher than with the Fraunhofer encoder. Here, quality comes at the cost of time: whereas the Xing encoder requires just 15 minutes per CD, the DOS-based Fraunhofer encoder takes ten times longer to complete the job.

The menu in detail

A table listing all control menu options and their effect is available as a .pdf document from our website at *http://www.elektor-electronics.co.uk*.
You'll find the table in the Free Downloads section, October 2000.

One final note regarding the MP3 Player. If you decide to buy OSCAR as a ready-made unit (see the Baycom advert elsewhere in this issue), you'll find that the analogue outputs are located on the switch-mode power supply board, rather close to the transformer. Our measurements indicate that the resulting 50-Hz stray signal was clearly noticed at about 20-30 dB above the noise floor. For the measurements discussed here, the Line signals were taken directly from the decoder board using short cables terminated in RCA (Line) sockets, as far away as possible from the PSU board.

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Software and links

Software to create and process MP3 files on a PC may be found at	
AudioCatalyst	http://www.audiocatalyst.com
MusicMatch Jukebox	http://www.musicmatch.com
Playback software for the PC	
Wimamp	http://www.wimamp.com
website dedicated to MP3	http://www.mp3.com
Information on MP3	
Info, tips, help	http://www.mpex.net
Basics (file 000044-11, May 2000	http://www.elektor-electronics.co.uk/dl/dl.htm

urls available as hyperlinks on the Hyperlinks page of the Elektor Electronics website.